Spark ignites physicists

Hertz's work on electromagnetism started as many arguments as it settled.

Dominique Pestre

Physics textbooks tell us that Heinrich Hertz discovered electromagnetic waves in 1888. In so doing, Hertz proved experimentally that it was James Clerk Maxwell's theory of electromagnetic radiation, and not the idea of electrical action at a distance, defended by continental physicists such as Hermann Helmholtz, that was right. While basically correct, this story also contains elements which are largely false.

The first to seize upon Hertz's publications were, of course, the British 'Maxwellians', as they were already convinced that Maxwell was right. They welcomed the news that the physics professor at Karlsruhe had found ways to produce electromagnetic waves, to have them interfere, and to measure their speed of propagation in air, which he found to be the predicted 300,000 km per second. They announced the result everywhere and began mounting public demonstrations of the marvel of the sparks induced at a distance by a Hertzian generator.

But it was J. J. Thomson who did the first quantitative experiments. He was intrigued by Hertz's claim that the speed of propagation in wires was 200,000 km per second, two-thirds of that in air. Thomson conceived a more refined experiment in wires, declared the speed of propagation to be the same as that in air, and said he had no idea why Hertz had been mistaken. Two physicists from Geneva, Edouard Sarazin and Lucien de la Rive, found a more disquieting result at the end of 1889. After conducting numerous experiments they claimed that, contrary to what happens in optics, the distance between nodes and loops depended crucially on the size of the detector used to make the spark.

A professor of physics at the École Polytéchnique in Paris, Alfred Cornu, used this finding to claim that Hertz's interpretation of his experiments was in trouble. Hertz's main hypothesis was that the generator produced a wave whose period T was unique and which he obtained by calculation. Hertz measured the distance L between two loops, from which he deduced the speed of propagation V. If L depended on the detector, Cornu concluded, T was not unique or V was variable. Either was problematic.

In the following months many physicists looked into these issues. Studies of the various parameters of this wonderful electrical phenomenon were undertaken, detectors and generators sprang up all over Europe, new setups were conceived, and diverse interpretations were put forward as solutions to the problem. Some people were unmoved. The British Maxwellians thought the problem was trivial. If the detector was tuned to the generator before starting the experiment (something Hertz had been careful to do, and which he considered a necessary condition), he was simply right — and the question of the other wavelengths was not essential and could be solved later. Hertz had got to the crux of the matter, and the Swiss physicists had found a marginal phenomenon.

Another French savant, the mathematician Henri Poincaré, identified another problem. While he thought that the approximations Hertz needed in his calculations were acceptable, he noticed that Hertz had made a mistake in calculating the period of his generator, and that he was wrong by a factor of $\sqrt{2}$. This meant that if Hertz had actually measured the length L between two loops, the speed of propagation was 300,000 km per second multiplied by $\sqrt{2}$. Poincaré did not make a lot of this, in contrast to what would probably happen today. Accepting the extraordinary complexity of the experiment, nobody hinted at forgery or fraud, nobody thought (as far as we can judge) that Hertz's results were too good to be true. Poincaré simply concluded that he was willing to reconsider the whole quantitative question with the help of his close friend and experimental colleague, René-Prosper Blondlot. As for Sarazin and de la Rive's results, he suggested that they were because of the damping of the wave.

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At no point did anybody doubt the decisiveness of Hertz's achievements. Many, many physicists entered the new domain and quickly performed experiments inspired by Hertz. All were able to generate sparks and 'play' with them, and all considered Hertz a true genius. On the other hand, most people were finally convinced by their own experiments, their own devices and calculations, their own way of adjusting proofs and expectations — and rarely by other people's (and in particular Hertz's) precise claims.

A fascinating indication of this is to be found in the textbooks published in the following two years by Hertz, Thomson and Poincaré. Each had his own story of what counted as a proof, and of what was decisive in securing the agreement of the community, and they differed profoundly. Hertz had made a major discovery, no doubt, but what he had proved, and who had decisively improved our understanding of this complex phenomenon, remained a matter of opinion. ■

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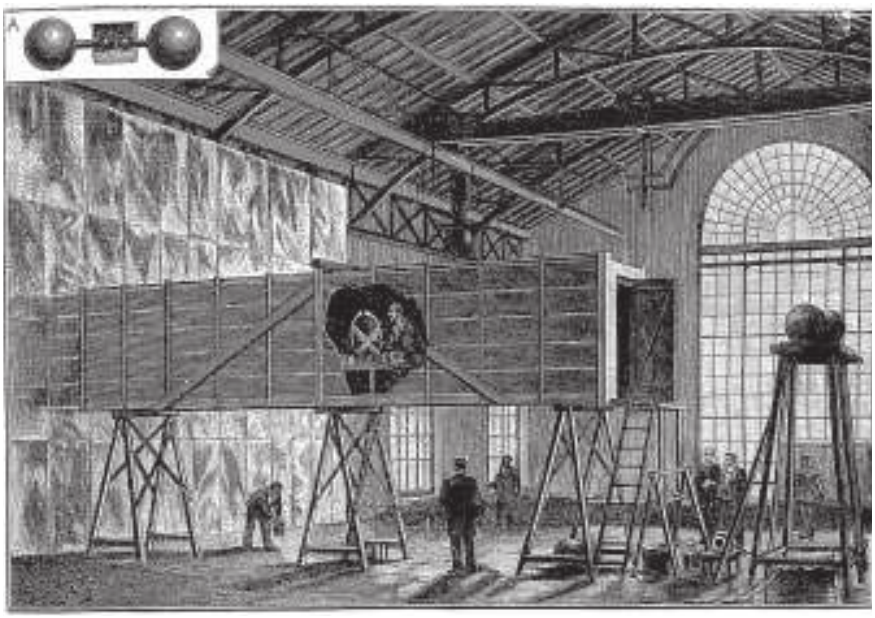

SELVA PHOTOS

Switched on: Sarazin and de la Rive try to replicate and extend Hertz's experiments with electricity.